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Notes on Some Characteristics of a Cold Front, February 11th, 1925

It has frequently been remarked that the study of certain atmospheric phenomena would be assisted by the use of autographic instruments with very open time scales. At the meteorological stations at Porton on Salisbury Plain and Leafield in Oxfordshire, some of the instruments, though they have not this advantage, have the merit that the record consists of a series of dots made at minute intervals so that with a little care the value of the element at a definite instant can be identified. The accompanying diagram, by Mr. N. K. Johnson, illustrates how the draughtsman can show on a sufficiently open scale the sequence of events. The original temperature records were made by Cambridge and Paul Thread-Recorders working with aspirated platinum resistance thermometers. Only the records for the dry bulb thermometer at 4 ft. above ground have been utilised in the diagram, but records for greater heights in addition are available for discussion. The wind records have been copied from charts with the time scale 15 mm. to the hour, use being made of a system of time-marking which permits of such accuracy in synchronising the records that the error does not exceed about one minute. For pressure the record of a microbarograph is available as well as the chart from an ordinary weekly barograph, but less reliance can be placed on the curve which has been sketched in our diagram to show the pressure than on the others.

Wt 69—P 1 1000 4/25 M & C

The following account of the events is based on Mr. Johnson's notes.

The secondary disturbance which crossed the south of England on the evening of February 11th, 1925, was remarkable for the large fall of temperature which accompanied the passage of the trough. Curiously enough this happened almost simultaneously at Porton and at Leafield. It will be seen from the diagram that a warm wind from the south was replaced very quickly by a cold one from the west. The wind velocity, which had fallen steadily from 35 m.p.h. at 20h. 45m. to 24 m.p.h. at 21h. 00m., then showed a sudden gust of 43 m.p.h. of about 2 minutes' duration. The wind direction was steady until 20h. 52m., it veered through 18° in five minutes and then through 75° in the next minute.

The temperature record shows that during the four minutes, 20h. 56m. to 21h., there was a fall of 12·9° F. As the mean wind velocity was about 25 m.p.h., the width of the transition cannot have been more than 1½ miles. This estimate makes no allowance for the lag in the thermometer; the lag is, however, very small. The wet bulb trace was steady at 46·5° F. till 20h. 57m. From 21h. 1m. it was superimposed on the dry bulb trace, showing that the cold air was saturated, presumably by the falling rain. There had been steady rain up to about 20h. 30m., and a rainless interval which lasted until 21h., then there came a heavy downpour with 1·4 mm. in 7 minutes; this was followed by steady but less heavy rain.

At Leafield, the structure of the cold front was somewhat different. Both the fall of temperature and the change in wind direction occurred in two well defined stages (Fig. 1). The first stage involved a change of temperature of 5° F. and the second one of 6° F. On the assumption that the wind velocity at Leafield was the same as that at Porton, these temperature differences would be distributed over horizontal distances of about 3 miles each and separated by an interval of 10 miles. The pause in the fall of temperature at Porton (from 21h. till 21h. 4m.) suggests a structure of the same type but developed to a smaller degree. The suddenness of the change in wind direction at Leafield at 20h. 54m. may be contrasted with the steadily commencing change at Porton. The Porton thermograms show that in the warm air the temperature at 56 ft. above ground was 0·7° F. higher than at that at 4 ft. Obviously the air was being cooled by contact with the ground. At the actual time of arrival of the cold front, the "inversion" changed suddenly to a lapse of 1·0° F., the new current being colder above than below. Eight minutes later the lapse was reduced to 0·1° F. and it became steady at 0·3° F., indicating that the air was being heated from below and well stirred by convection. The wind velocity trace already

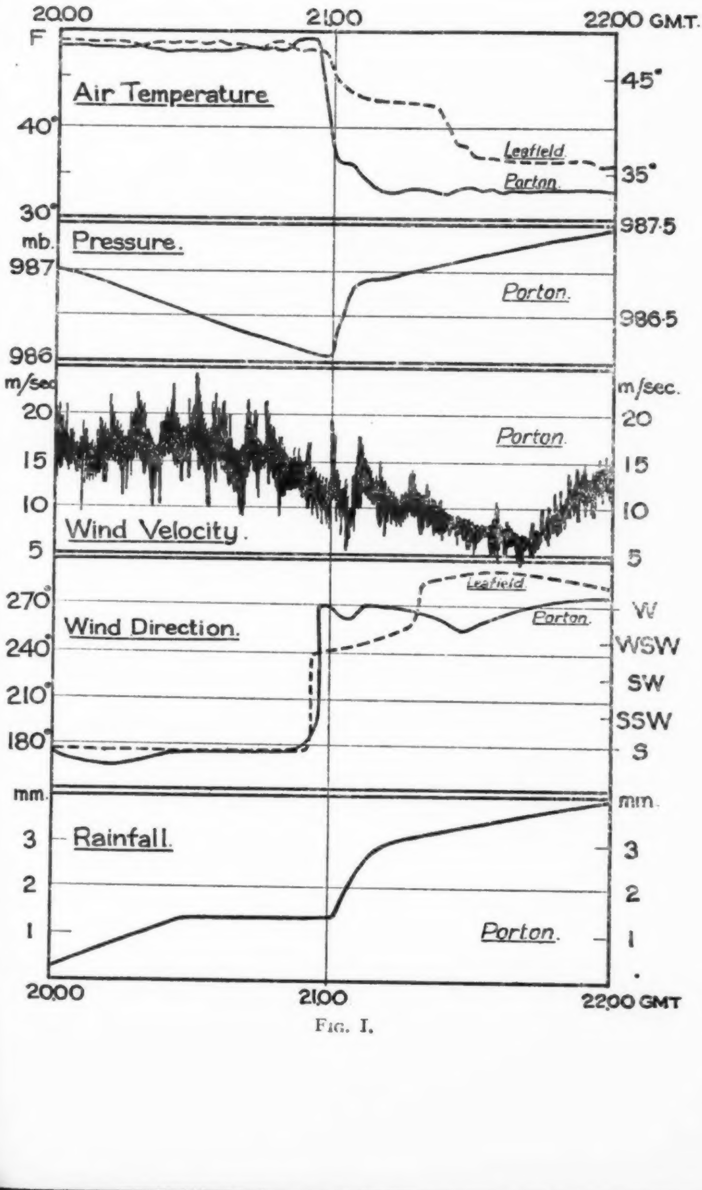

20.00
21.00
22.00 G.M.T.
F
Air Temperature
40°
30°
45°
35°
Leafield
Porton
mb.
Pressure.
987
986
987.5
986.5
Porton.
m/sec
20
15
10
5
m/sec.
Porton.
Wind Velocity.
270°
240°
210°
180°
Wind Direction.
Leafield
Porton
W
WSW
SW
SSW
S
mm.
Rainfall.
3
2
1
mm.
Porton.
20.00
21.00
22.00 GMT

FIG. I.

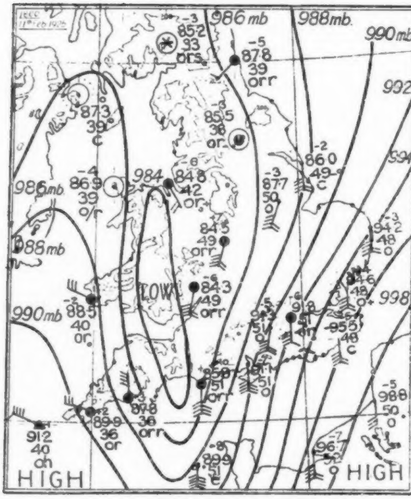


FIG. 2.

referred to in Fig. 1, shows a smaller gustiness after 21h. than before. The reason is to be found in the better exposure of the anemometer to the west as compared with the south.

In comparing the differences between the structure of the "cold front" at Porton and Leafield, reference may be made to the synoptic chart for 18h. on the date in question (Fig. 2). In the latitude of Leafield the chart indicates a difference of 9° F. in the temperatures of the equatorial and polar air (Ross 49° F., Pembroke 40° F.). Further south (Portland Bill, Cattewater) the temperature fall is 15° F. The temperature of the polar current as a whole would be lower, however, than those recorded at Pembroke and Cattewater where the air must have been warmed by the sea. The position of the "warm front" at 18h. is very clearly shown as extending in a straight line from Flamborough Head to about Shrewsbury. The warm current rising over cold air in the north of England is responsible for continuous rain over that area. On the same chart the "cold front" is along the trough of the depression from Shrewsbury southwards.

The history of this cold front invites further study with the aid of other autographic records. The reason for the belt of air of intermediate temperature might be found as well as the cause of the absence of rain in this belt. That the heavy rain at Porton began three or four minutes after the first fall of temperature may be due in part to the fact that rain takes an appreciable time to fall. In heavy rain at the rate ·01 in. per minute the drops would fall at about 15 ft. per minute and, if the cloud was 3,000 ft. up, they would take about three minutes to reach the ground. Moreover, the manufacture of the rain by the ascent of warm air over a wedge of cold air must take time, so that the cold front would have reached the station before the rain-cloud came overhead.

Another interesting point that is brought out by the records is

the contrast between the types of wind in the warm and cold currents. The warm current was well established. It had been following the same course for many hours. The position of the warm front was very stable. A straight line can be drawn on the map from near Scilly to Flamborough Head, separating the places which were reached by the warm current and had high maximum temperatures, from those with low maxima. The warm current was flowing very nearly along the isobars. On the other hand, the cold current from the west seems to have been nearly at right angles to the isobars in the region where pressure was rising. This contrast between the behaviour of winds in semi-permanent and in changing fields of pressure is of great interest.

In conclusion let us emphasize the desirability of obtaining a few true autographic records with an open time-scale. The present note demonstrates how the exact sequence of events on certain occasions cannot be traced unless time is measured by seconds. With the ordinary records it is only by a *tour de force* that minutes can be estimated.

Discussions at the Meteorological Office

March 16th, 1925. *Diagnostic and prognostic application of mountain observations.* By J. Bjerknes (Christiana, Geofys. Pub. Vol. III, No. 6). *Opener*—Mr. F. J. W. Whipple.

It is curious that in the development of their methods of analysis of weather sequences the meteorologists of the Norwegian school made little direct appeal to upper air observations. They studied the appearance of the sky, the times at which rain occurred, and the temperature changes on the ground, and learned from these the movements of the upper winds. Mr. J. Bjerknes has now taken advantage of a visit to Switzerland to study the records of mountain observatories. In this paper he discusses the records for three days, January 31st—February 2nd, 1923, and shews in particular how a "warm front" is modified as it crosses the mountains.

It is interesting to note that in this diagnosis an important part is played by a "surface of subsidence." Over a cold surface current there is a current of drier, warmer air moving in nearly the same direction but more slowly. The boundary between these currents is a surface of subsidence. Bjerknes prefers this name to that adopted by Stüve, Abgleitfläche. The idea is that the air of the upper current is in origin identical with that in the lower, but that it has been dried and warmed by compression during subsidence and lateral spreading. In this particular instance, and we are led to believe that it may be regarded as the general rule, there was a definite inversion of temperature at the

surface of subsidence whereas there was no inversion at the boundary between the main warm and cold currents.

Admitting responsibility for the false idea that the warm front and cold front surfaces should necessarily show true inversions of temperature associated with high relative humidity above and low underneath, Bjerknes now considers that such inversions are rare. As was mentioned in the discussion this is in accordance with the results of an investigation* by W. H. and L. H. G. Dines.

The second part of Bjerknes's paper is devoted to the development of mathematical machinery whereby the acceleration of air masses may be computed in certain circumstances. Perhaps the most useful result is that if a fast moving upper current is over-running a slower under current, the pressure gradient appropriate to the upper current will be more than is required to balance the geostrophic force of the lower current, and the air of this lower current will therefore have an acceleration to the left.

A numerical example in which the data are derived from the observations of the first part of the paper brings out the utility of this analysis and so justifies the words of the title "Diagnosis and Prognosis."

Royal Meteorological Society

THE monthly meeting of this Society was held on Wednesday, March 18th, at 49, Cromwell Road, South Kensington, Capt. C. J. P. Cave, M.A., President, in the Chair.

Sir Napier Shaw, F.R.S., and H. Fahmy, D.I.C.—The energy of saturated air in a natural environment.

In classical thermodynamics the idea of "entropy" plays an important part. The idea is very difficult, and to most students elusive; perhaps that is why the efforts which Sir Napier Shaw has been making for many years to persuade meteorologists to consider entropy when dealing with atmospheric problems have met with little success. On the other hand, potential temperature is a comparatively simple conception. We can imagine a mass of air which is actually at low pressure and low temperature in the upper atmosphere being compressed without loss of heat until it is brought to ground level pressure and to a relatively high temperature. This is the "potential temperature" of the mass of air, and it is easy to see that for an atmosphere to be stable, the air with the highest potential temperature must be at the top. Now it so happens that the entropy of a certain mass of dry air is proportional to the logarithm of its potential temperature. The practical application of this fact is the most important advance in the present paper. The conditions of a sample of air can be represented on paper

* *Meteorological Magazine*, 58 (1923), p. 84.

ruled to show temperature on an even scale and potential temperature on a logarithmic scale. The resulting diagrams have the advantage that the co-ordinates are readily comprehensible, and at the same time the advantage which pertains to the idea of entropy, that quantities of heat are represented in the diagram by areas. In the atmosphere we have to deal with saturated air as well as with dry air, and the authors have shown how the properties of saturated air can be exhibited on the new scales and compared with the properties of the actual atmosphere as determined by upper air soundings. Plotting paper has been printed with the special ruling, and will facilitate further investigation on these lines.

C. K. M. Douglas, B.A.—On the relation between the source of the air and the upper air temperature up to the base of the stratosphere.

In his well-known investigations of the relation between the temperatures of the upper air in systems of low and high pressure, Mr. W. H. Dines correlated temperature and wind direction, and found little connection between them. He came to the conclusion that the temperature changes in the air over any one spot were due to the pressure changes rather than to the variation in the source of the air supply. Capt. Douglas, starting with the idea that the direction in which air happens to be moving at the time is not a fair indication of where it has come from, has proceeded to the detailed study of numerous cases, tracing back the air currents to see where the air was situated three days before the temperature observations. The result of his work is that there is a very high correlation between the temperature of the air and the latitude from which it has come. This result lends support to the theory that cyclones are cold because they are constituted mainly of polar air.

A. H. R. Goldie, M.A.—Waves at an approximately horizontal surface of discontinuity in the atmosphere.

In this paper the author shows how the oscillations of the atmosphere shown by clouds as well as by autographic records may originate in the transition layers between currents of warm and cold air.

Correspondence

To the Editor, *The Meteorological Magazine*

Convective Circulations in the Atmosphere

WILL you allow me to transgress on your space to amplify slightly my note on Convective Circulations in the Atmosphere in the February number?

In a letter which I have recently received, Professor Bénard

points out that one of the first observations which he made of cellular structure in fluids, was made involuntarily in 1898, when he introduced bronze filings into melted paraffin wax in an attempt to make a solid coherer for early experiments in wireless telegraphy.

The first attempt to utilise the cellular structure in explaining atmospheric phenomena was made by M. Deslandres in the Annales de l'Observatoire d'Astronomie physique de Paris, tome IV, 1ère partie, pp. 119-123. This was stated in very general terms however.

I find from Professor Bénard that there is in French a fairly considerable literature dealing with possible applications of cellular structures in fluids. Cellular solidifications are considered in great detail in an interesting thesis by C. Dauzère, now director of the Meteorological Observatory of the Pic du Midi. M. Bénard, in a paper in Comptes Rendus, t. 154, p. 260, has discussed a possible application to explain the lunar craters by the stresses set up in a solidifying surface layer. A photograph of a wax model which actually shows craters with a central cone, from an experiment of M. Dauzère, is reproduced in this paper.

In *Nature*, February 28th, 1925, Major A. R. Low discusses a possible explanation of the polygons of stones found in the mud flats of polar regions, on the basis of cellular circulation in thick mud.

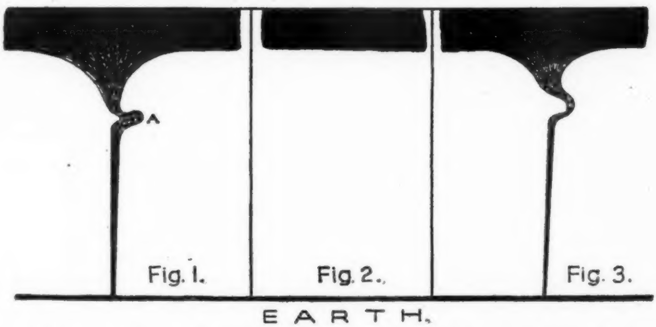
D. BRUNT.

April 6th, 1925.

A Recurrent Cloud Pendant

AT about 2.30 p.m. this afternoon while my son and I were out for a walk we saw a most wonderful sight. There had been brilliant sunshine earlier and it was quite hot, but about 2.30 a violent thunderstorm came on, and looking in the direction of the storm we saw something I have tried to represent in Fig. 1 ; it was black and disappeared up in the cloud above, breaking at the earth end. The blackness passed upwards leaving uniform whiteness below as it travelled up ; at A it broke in a violent vortex motion, and in a short time the whole effect had disappeared. Fig. 2 represents this case, the black cloud assuming a level bottom surface again. After another short period the black portion again started from the earth as if some material were filling up an invisible tube, this rapidly rose, giving again as nearly as possible the same picture as in Fig. 1—represented by Fig. 3—this again broke at the earth and left everything blank again as in Fig. 2, when whatever it was had been literally thrown violently into the black cloud. This sequence of events went on time after time. The black streak

without the slightest doubt represented or corresponded to a flash from the cloud to the earth, that we had not seen. We watched this going on for quite a considerable time, one cannot say quite how many minutes. The straight line or narrow cone remained quite definite and sharp every time it occurred in what was just before a blank space. It was the same tube rendered visible at intervals by the uprushing blackness. As I said before, it started at the earth end filling up the tube until it produced what I have tried to draw, then broke near the earth and travelled up into the black cloud with a great rush, leaving everything below blank until the same thing repeated itself.



We were a good distance from home, and when we thought it unwise to delay any longer the phenomena was still going on.

The explanation may be that the flash struck ground that was water covered, the intense heat produced a vacuum in the patch of the flash, water was sucked up until there remained no more local water, then the break at the earth would occur; water would next flow in from the surrounding parts, to be again sucked up, and so on, time after time. I suppose that had the flash struck a lake instead of water-covered ground, a regular water spout would have been produced, instead of the intermittent effect which we observed.

It is hard to imagine that the well-defined sharp figure could have repeated itself so many times and could last so long; its presence being only visible or made manifest, each time the water rushed up.

How far my attempted explanation may be right, I cannot say, something did pass from the earth to the cloud time after time, rushing into the cloud in much the way shown, while after each occurrence the cloud recovered its level black appearance. The blackness of the "Flash Path" is not exaggerated in the

drawings, one could hardly draw it too black. The narrow cone part was so sharp that it would be best drawn with drawing pen and straight edge.

EDWARD E. ROBINSON.

Mount Lee, Egham Hill, Surrey. March 1st, 1925.

[It is probable that the cloud pendant was the manifestation of a local whirl and had no direct association with lightning. The apparent stiffness of the pendant is, however, a feature which is not usually mentioned in reports of such phenomena. —ED. *M.M.*]

Abnormal Weather in Rhodesia

I was interested to note your request in the December issue of the Magazine for the early report to you of any abnormal conditions, and in future I will do so by cable. The early publication of reliable information of this nature will undoubtedly be of great value.

The present rainfall has in some respects been an abnormal one in southern Rhodesia. The " early rains," during the period October to December, which are mainly associated with southerly " lows," were abnormally heavy. The mean rainfall over southern Rhodesia during this period amounted to 16·8 in., *i.e.*, 6·9 in. above normal, the previous highest total for this period was in 1917, when the mean rainfall to the end of December was 16·5 in. The usual spell of fine weather between the " early " and " general " rain periods did not occur this season, and the " general " rains, which are mainly associated with movements of the equatorial low, have also been exceedingly heavy.

There were four incursions of the equatorial low during the month of January; the daily pressure at Salisbury was never above normal during the whole period January 1st to February 19th, and the mean pressure at Salisbury during January was 0·097 in. below normal, the previous lowest being in January, 1918, when the mean pressure was 0·054 in. below normal.

C. L. ROBERTSON.

Dept. of Agriculture, Salisbury, Rhodesia. February 20th.

" A Plunge Through a Line Squall "

IN accordance with your request in the February number of the *Meteorological Magazine* (p.13), I am sending you an extract from my diary of December 31st, 1924.

> " An extraordinary squall at 14h. 30m. of wind and hail which only lasted about 10 minutes, when the sun came out. It was so dark during the squall that I could hardly read by the study window."

There were two similar squalls here on March 8th. All three

agree in their main features: they begin with a darkness so great that reading is almost or quite impossible. With this comes a high wind and a heavy fall of snow or hail lasting about 20 minutes. No thunder or lightning on either occasion. These squalls appear to me to have a well defined form deserving a name, but I do not think "Line" expresses their character, even if you think they belong to that class. "Dark" squalls would be more appropriate.

My house is 7 miles south-east from Maidstone on the south slope of the Lower Greensand ridge, close to Ulcombe Church. Ulcombe is 7 miles north-east of Mardon.

ALFRED O. WALKER, F.L.S.

Ulcombe Place, Maidstone. March 17th, 1925.

Excess of Salt in Rain

DURING the past winter I have tested the rain for salt after a very strong wind from the west and have obtained the following results though I am 6½ miles from the sea: 226, 72, 140 and 60 parts NaCl per million. I think the 1st and 3rd are almost phenomenal. Another test taken after a gale also from the west, but preceded by a few days of calm, showed only about 12 parts NaCl per million, which seems to show that the sea has to have a few days of storm before it begins to scatter the salt over the land.

The average proportion of salt in the rainfall here is about 8 or 9 parts per million. It is generally higher in the winter, and in the three months October-December, 1920, it averaged 37.* At Maryport on the sea coast I have often had 200 parts during a gale, and in fact for the three months referred to, the average was 199.

WILFRID IRWIN.

Derwent Lodge, Cockermouth. March 10th, 1925.

High Barometer and Heavy Rain

As an addition to the interesting notes by the Rev. R. P. Dansey in the *Meteorological Magazine* for February, 1925, on high barometer and heavy rain at Kentchurch Rectory, Hereford, on January 26th, I should like to append a few remarks of my own. On the day in question the rainfall here was only 0·01 in. with an east wind, but we had in Nottingham in November, 1924, a very similar experience to that of Hereford in January last. On November 11th, 1924, 0·75 in. of rain fell here (the fourth highest downpour of the year). The rain came on with the barometer about 30·25 in. and steadily rising; wind 1 p.m. south-west. When I visited the gauge on the morning of the 12th the baro-

* *British Rainfall*, 1920, p. 276.

meter was about 30·5 in. Most of this heavy rain fell with the barometer between 30·25 in. and 30·35 in., and is by far the most noteworthy example of heavy rain with a high barometer on my records of 18 years (not wholly in Nottingham).

The nearest approach was on August 14th, 1923, when 0·58 in. of rain fell here with the barometer steady about 30·2 in.; wind 1 p.m. west, light. One of the most interesting cases was on February 25th, 1921, when 0·31 in. of rain occurred in about four hours, with the barometer rising from 30·35 in. to 30·45 in., this being practically the whole of the total rainfall for that very dry month (0·34 in.).

Taking the arbitrary double standard of ·20 in. of rain and a barometer of 30·20 in., I find that, in the 18 years I have recorded, only 10 cases reached these limits.

ARNOLD B. TINN.

107, *Burford Road, Nottingham. March 2nd,* 1925.

The Dew Pond Myth

IT would seem that every two or three years it is necessary to repeat the exposure of the Great Dew Pond Myth, as it has been rightly called. Every now and again one or other of the newspapers starts a correspondence on the subject, and the old unsubstantiated statements are made afresh.

May I ask your indulgence in order to add a few words to your notes on the subject in your January issue? I quite realised the difficulty of measuring the rainfall on the open downs. I considered and still do consider that a pond depression receives more than the normal rainfall, and that it was in consequence of the eddies set up that more rain came to rest in such a depression than on the downs around. The words which you are good enough to quote from my book, show that the gauge which I compared with the one inside the pond depression was situated outside the bank, that is, it was on the open downs. On any other supposition than that this represents the normal rainfall on the down, it would mean that if we had half a dozen gauges at a few yards distance from one another they might all differ, as some would be more sheltered than others, and that only where sheltered they would represent the true rainfall. If there were a driving rain from the south-west and the rain were falling at an angle of 50 degrees with the ground, any temporary cause which made the rain fall in any one place vertically would result in a greater amount of rain falling there. But as I take it, rain is measured as it falls, and this is not always necessarily at right angles to the ground, otherwise it would be necessary to correct the actual observation when not falling vertically, a not frequent occurrence on the downs.

As regards the observation, that you suspect that ·25 in. would have been a better estimate of the rainfall when the pond rose ¼ in., that could only be the case if there were no margin round the pond and the sides of the pond were vertical. But round a pond there is a collecting margin, and in some ponds this area is as much as twice that of the pond surface. Clearly there is drainage from this area into the pond, and I must adhere to the measurement of my gauge which showed ·11 in.

I should like also to refer to the matter of the sea-mists. They appear as a rule before the winds reach the hill-tops, and I have watched them coming up the valleys, always then on the move. No doubt they receive fresh accessions of mist as the air rises to pass over the hills. On page 36 of my book, I have referred to the formation of mist on the hill-top and likened it to the fresh condensations of vapour which Tyndall observed on the lee side of the Matterhorn, the cloud appearing to be stationary, although in reality made up of fresh condensations of vapour. But I have not contended that all the mists come up from the sea. On page 181, I wrote—" In the early morning I have seen the mist gradually forming not only in the valleys, but on the hills. Not always do they creep up the valleys from the sea, as has been alleged." That there is an actual movement of the air from the sea sometimes is, I think, shown from the amount of sodium and chlorine found in the ponds, as also in the soils. In the analyses of pond waters which I have given, this is plainly shown, and it is also shown that the chlorine content is the smallest in the ponds farthest from the sea.

I am afraid that I do not agree that ponds without bushes are equally successful in retaining water throughout the year. But the difficulty is how to get bushes to grow in the exposed places of the downs, so that their drip is into the pond. Where it has been done, however, the result has been remarkable. The comparison between Piddingworth pond (No. 21) and High Park Wood pond (No. 31) shows this clearly, the former receiving very much drip and the latter none. They are not very far apart.

I was glad to note Walford's article in " Discovery," as every opportunity is necessary to point out the widely believed fallacy of the dew pond, and I hope his remarks will be widely read.

EDWARD A. MARTIN.

285, Holmesdale Road, South Norwood, S.E. January 6th, 1925.

[The point with regard to rain-gauge exposure is that if a gauge is set up on open land with no shield round it, the wind striking the gauge eddies up over the top and blows away some of the drops. The error is instrumental rather than topographical. The question is discussed in Mr. Salter's book " The Rainfall of the British Isles," pp. 65 and 273. Ed. *M.M.*]

NOTES AND QUERIES

The Green Component in Auroral Light

THE following communication from Professor J. C. McLennan was published in *Nature*, March 14th, 1925:—

"Dr. Shrum and I have observed in the spectrum of a mixture of air and helium, with the latter in excess, a line at $5577 \cdot 35 \pm 0 \cdot 15$. Mixtures of oxygen and helium give the line enhanced approximately to one-half the intensity of each of the yellow lines of helium.

"A long discharge tube was used, surrounded over part of its length with liquid air, and the best results were obtained with a pressure of about five millimetres of mercury. The line was not observable in the spectrum of purified oxygen, hydrogen, nitrogen or helium. No mixtures of any two of these gases other than oxygen and helium gave this spectral line.

"The line is narrow, very sharp, and well defined, and these characteristics, together with its wave length and the conditions under which it is observable, point to its identity with the auroral green line."

It will be remembered that a year ago Professor L. Vegard announced that he had identified the green auroral line as one of the components of the light emitted by solid nitrogen when submitted to bombardment by electrons, but that when the details of the experiments were published it appeared that the identification was not fully established. Professor McLennan and Dr. Shrum, working with more delicate optical apparatus, satisfied themselves that the spectrum of glowing solid nitrogen did not contain a component of the appropriate wave-length. Moreover, it was known that the investigation by H. D. Babcock, in which the wave-length of the auroral line was determined precisely as 5577·35 Angström units, led to the conclusion that if the light proceeded from a gas at a temperature such as that of the upper layers of the atmosphere, that gas must be helium. The discovery by McLennan and Shrum, quoted above, is therefore in accordance with Babcock's observations. It remains to be seen under what conditions the green light from helium and oxygen is intensified so as to produce the predominant characteristic of the auroral light. Meanwhile, Professor Vegard is still pursuing his own line of investigation, as may be seen from the following cable sent by him to *Nature* on March 20th:—

"Shown by experiments in mixtures of nitrogen and neon at the Leyden Laboratory that auroral line is the limit to which the band N_1 approaches by diminishing size of nitrogen particles."

A Personal Investigation of a Squall Cloud

THE following note by Mr. D. L. Webster appears in the *Monthly Weather Review* (Washington), December, 1924. It is of such interest that we venture to quote it in full.

"In the very interesting discussion of thunderstorms given by Dr. W. J. Humphreys in his 'Physics of the Air,' the explanation of the squall cloud, or roll scud, is especially significant because that cloud is often so different in appearance from the main mass of cumulus clouds above it, and because its explanation as a result of interaction between the upward and the downward currents is such a neat confirmation of the general theory. Because of these facts, direct observations of the motion in such a cloud are of some interest. As Doctor Humphreys informs me that records of such observations are quite rare, and I happen to have had an exceptional opportunity to make one, I venture to contribute this note in confirmation of the theory.

The occasion for this observation was a cross-country flight in October, 1918, in which Professor, then Major C. E. Mendenhall and I were over the lower Rappahannock River, Va., in a Curtis JN4H, a small but fairly powerful plane, just as a thunderstorm was getting well started. Having read Doctor Humphreys' description, and seeing a well-developed roll scud under the forward side of this storm, I decided to investigate more closely.

I had had some previous experience with the saw-tooth shaped points that often appear on the tops of fracto-cumuli subject to overrunning winds, and had noted in them eddies with horizontal axes, that could roll an air-plane flying through them remarkably suddenly. In fact, since there is plenty of room in which to recover equilibrium, such clouds make interesting opportunites for a form of safe and sane acrobatics different from those possible in still air. It appeared reasonable, therefore, to expect to confirm Doctor Humphreys' statement as to the probable rolling motions in the roll scuds, by flying into it at a small angle, so as to be headed almost along its axis, and seeing whether the airplane would likewise roll with it.

This expectation was not only confirmed, but confirmed to such an unexpected extent that the strain on the wings caused them to creak with a scream audible even through the roar of the motor. I promptly brought the machine up into a stall, to reduce the strain by reducing the air-speed, and dropped out of the cloud rolling with all the angular velocity that the most ardent upholder of this theory of thunderstorms could wish for.

The conclusion is that the theory is confirmed, as far as such an observation can confirm it, but that the experiment shares one characteristic with the famous thunderstorm experiment of Benjamin Franklin, namely, that its repetition is most decidedly inadvisable."

Wind Fluctuations in the Free Atmosphere

SOME results obtained with a pressure anemograph mounted on a captive balloon at the school of aeronautics at Petrograd have been published recently* by S. Troïtsky.

The anemograph used was Kalitin's. The reproductions show an open time-scale about one centimetre to the minute, whilst 1 metre per second is represented by 2 centimetres. There is a great contrast between the records obtained at different seasons. In winter when the stratification of the air is stable the fluctations in wind strength are very small. In summer on the other hand the fluctuations are large. At 500 metres above ground, the seasonal averages for the ratio of the amplitude of the fluctuations to the mean wind strength are ·035 and ·25 respectively. In certain cases changes of wind observed in the upper layers gradually descend to the ground. For example on one occasion a steady wind was replaced by a turbulent one of greater strength; at 375 metres above ground the change took place at 8h. 47m., at 250 metres at 9h. 2m., on the ground at 9h. 30m. The author does not seem to have noticed that the phenomenon can be pictured as the advance of a surface of discontinuity. If the surface was moving with the speed of the wind below it, *i.e.*, 5 metres per second, it would travel 13·5 kilometres in $\frac{3}{4}$ hr. The slope of the surface would be about one in 35.

An attempt was made to compare the time of occurrence of the maximum wind strength in the gusts aloft and on the ground. The maximum was found to be later on the ground, the lag being of the order 20 seconds when the balloon was at 500 metres. It is concluded that the fronts of the air waves are inclined forward in the direction of travel. It is to be hoped that this interesting generalization will be tested elsewhere.

The Airship R 33

THE successful flight of R 33 from Cardington (near Bedford) to Pulham (Norfolk) on Thursday, April 2nd, was an event of considerable importance, since it was the first flight of a British airship under the new scheme of airship development. Meteorologically the operation was interesting as it set a definite problem in precise forecasting. Owing to structural alterations at one end of the shed at Cardington, there was no choice as to which end the ship should be brought out, and it so happened that the only way was stern first. This necessitated a calm or very light

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* Quelques données sur la question du développement et de la propagation verticale des ondes aériennes. S. Troïtsky. *Recueil de Géophysique publié par l'Observatoire Physique Central.* Tome IV., Fascicule 2. Petrograd, 1924.

wind (less than 5 m.p.h.) for complete safety, owing to the fact that the elevators would become exposed to the wind before the rest of the ship was clear of the shed. A desire to carry out the flight by day made an early morning start most suitable, but for this the handling party had to be warned the previous afternoon. The problem then was to forecast on the 1 p.m. chart an early morning calm for the next morning.

On Wednesday, April 1st, the pressure distribution was very "flat" over England, and calm conditions were clearly probable during most of the following night, but a depression had already commenced to spread over the country from the north-west. It was decided, however, to warn the handling party to assemble early the next morning. Later charts supported this decision, and a limit was set at 6 a.m., by which time the ship must be out of the shed. The operation was carried out at about this time, and shortly afterwards the wind rose to 10 m.p.h., and later to 20 m.p.h. from the south-west, the gradient having already increased appreciably during the night.

It would not be right to emphasise this particular instance of an airship's dependence on specially favourable weather conditions without at the same time pointing out that, but for the progress already made in airship development, the ship would never have been brought out at all at a time when a depression was spreading over the country. She was, however, to be moored at the mast at Pulham, an operation which has already been shown to be practicable in all but very bad weather. The main difficulties in handling airships arise in connection with entering and leaving sheds, but in the future these will merely be "dry docks," and between journeys the airship will rest at its mooring mast.

This good beginning is a favourable omen for the future of the Imperial Airship Service.

The Long Arm of Coincidence

In the rainfall totals as reported year by year from the many stations in the British Isles, some curious coincidences are often noticed. Some examples were given in the *Meteorological Magazine* for 1924, *pp.* 16 and 61. Another striking instance is set out below :—

Station.	1921.	1922.
Much Hadham	13·08 in.	24·12 in.
Royston (Therfield Park)	13·08 in.	24·12 in.

The two stations are both in Hertfordshire, situated some 15 miles apart. The monthly totals, although similar, are never identical, and differ in some cases by as much as half an inch.

J. G.

Distributive Stations of the Meteorological Office Aviation Services

A list of the Distributive Stations of the Meteorological Office and their Auxiliary Reporting Stations as at present established is given below.

This list supersedes that given in the *Meteorological Magazine,* January, 1923, p. 342.

The various types of stations are indicated by the letters in the first column.

Type.	County.	Station.	Lat.		Long.		Height above M.S.L.	Officer in Charge.
			°	′	°	′	Ft.	
R	Fifeshire	Leuchars	56	23	2	52 W	40	W. Gillon.
C	Renfrewshire	Renfrew	55	52	4	24 W	36	J. J. Somerville.
C	Antrim	Belfast	54	34	5	59 W	91	W. Andrews.
AU	Anglesey	Holyhead	53	19	4	37 W	26	H. L. Pace.
RI	Flintshire	Sealand	53	13	3	0 W	16	H. F. Jackson.
RI	Lincolnshire	Cranwell	53	2	0	31 W	236	W. H. Pick.
C	Warwickshire	Castle Bromwich	52	31	1	48 W	269	E. V. Stone.
R	Devonshire	Cattewater	50	22	4	8 W	82	W. L. Andrew.
R	Hampshire	Andover	51	13	1	31 W	295	G. L. H. Douglas-Lane.
RI	Hampshire	Calshot	50	49	1	17 W	10	J. Durward.
U	Hants, Isle of Wight	St. Catherine's Point	51	27	1	17 W	120	Coastguard.
RR	Hampshire	South Farnborough	51	17	0	45 W	230	H. St. G. Dyke Marsh.
C	Surrey	Croydon	51	21	0	7 W	244	G. R. Hay.
RR	Suffolk	Felixstowe	51	57	1	20 E	21	C. W. Lamb.
RU	Kent	Biggin Hill	51	19	0	2 E	597	E. L. Clinch.
C	Kent	Lympne	51	5	1	1 E	350	R. M. Stanhope.
U	Sussex	Beachy Head	50	44	0	15 E	525	Coastguard.
U	Kent	Hythe	51	3	1	5 E	5	Coastguard.
U	Kent	North Foreland	51	22	1	27 E	188	Officer i/c, P.O. Wireless Station.
U	Kent	Deal	51	13	1	24 E.	20	Coastguard.

C—Civil Aerodrome.
R—Royal Air Force Station.
RI—Royal Air Force Station (Regular Lectures and Instruction given in Meteorology).
RR—Royal Air Force Station (associated with Research or Design).
A—Experimental Anemometrical Station.
U—Auxiliary Observing Station.

Possible Cotton-Growing Areas

Mr. E. E. Canney has recently published a useful note on the areas which have a suitable climate for the growth of cotton without irrigation.* He enumerates three essential climatic

* Canney, Ernest Everett. "Rain-grown cotton and climate." *Journal of the Textile Institute,* vol. 15, p. 1533.

factors : freedom from frost during the growing season ; adequate but not excessive rainfall ; and abundant sunshine ; and he points out that the cloudy humid climate of large areas of the tropics is fatal to the economic production of good quality cotton. For the practical limits he takes :—

1. A mean annual temperature above 60° F., or where the climate is otherwise very favourable, 50° F.

2. A rainfall of between 20 and 60 in. per annum, the upper limit rising to 75 in. when other conditions are favourable.

3. A mean cloudiness of less than five-tenths ; areas with a cloudiness of six-tenths or more are regarded as extremely unsuitable.

The altitude limit is about 2000 ft. in latitude 25°, and 4000 ft. on the equator.

On this basis, maps have been prepared showing the possible cotton-growing areas, and the conclusion is reached that " there is enough land with suitable climate awaiting development to grow as much cotton as will be required for many generations." The exact delineation of the suitable areas, however, is not yet possible in many regions owing to the paucity of meteorological observations in the tropics.

Meteorological Instruments

A new catalogue of thermometers, hydrometers and pressure gauges has been issued recently by Messrs. C. F. Casella and Company, Limited. Amongst the instruments of special interest to meteorologists the bimetallic thermograph and the Assmann psychrometer may be noticed. The thermograph is listed at the moderate price of £7 10s.

Recent developments of meteorology have emphasised the value of continuous records of temperature. Observers realised long ago that if they wanted to follow the changes in the weather they should have barographs to supplement their barometer readings. Thermographs should now become equally popular. Incidentally it may be asked why instrument makers show in their catalogues what instruments like barographs and thermographs look like but very seldom reproduce records to show what they can do.

The manufacture of psychrometers of the Assmann pattern was commenced by Messrs. Casella during the war. It is well known that the reading of a wet-bulb thermometer depends on the strength of the air current past it. In the Assmann psychrometer a strong air current is produced by a clockwork fan, and consistent readings are thereby secured. The instrument is the most convenient available for determining the humidity of the air with precision. It is satisfactory to know that the

psychrometer is being manufactured in this country ; it may be recalled that the first instrument of this kind in which the dry and wet bulb thermometers were ventilated by the suction of air past them was devised by Welsh,* in 1852, for use in balloon voyages. Welsh used bellows for his aspirator.

The Course of Thunderstorms

THE relative frequency of thunderstorms at different places in the same neighbourhood would be an interesting subject for study by the members of a local scientific Society. From time to time observers make such remarks as "thunderstorms seem to have a particular objection to our little valley and go north of us over the Downs or else along the valley of the main river." On the other hand none report that they have more than their fair share of the storms. It is clear that a single observer cannot decide a question of this sort for himself. It would facilitate the discussion if we knew for the average station on open flat country the ratio between the number of thunderstorms which come within 10 miles to the number which actually pass over the station.

Some Works by Luke Howard

THE author's copy of Luke Howard's *Lectures on Meteorology* has been presented to the Meteorological Office by his grandson, Mr. E. Howard, of Ardmore, Essex, as well as a copy of *Barometrographia*, with the inscription "Robt. Howard, Tottenham, 1853. A present from his affect^e. grandfather, L.H."

The Lectures, written in 1842, present the facts "in a familiar and intelligible way." These lectures are probably of most interest now as affording a criterion by which to measure the advance made in meteorology during the past century. The physical properties of water vapour in the atmosphere and the more common optical phenomena are explained very much as they would be in a modern, popular treatise on meteorology. Whirlwinds, waterspouts, thunderstorms, aurora and meteors are ascribed vaguely to electrical causes which are almost meaningless in the light of modern physics.

"In the year 1814," Howard writes in the Introduction to *Barometrographia*, "an opportunity presented of possessing myself by purchase of a clock made by *Cumming*, on the face of which *the autograph of the curve*, made out by the rise and fall, is described by a pencil resting on the quicksilver in the short leg of the siphon while the scale revolves." Cumming, it appears, made the first instrument of this type about 1765 ; one was made

* London, Phil Trans. R. Soc. 1853, p. 311.

for George III., and another for the Earl of Bute. In *Barometrographia* the records are reproduced full size. The record sheet, some 17 inches in diameter, was turned slowly by the clock so as to make one revolution a year, so that the fluctuations of pressure for a year are conveniently presented in a single diagram.

Howard took advantage of the inner part of his records to write a weather diary and utilised other space for a general account of the weather of each year in the British Isles ; these " Historical and Illustrative " notes contain a useful summary of the notable weather of the years 1815-1834. A description of the frozen Thames in the winter of 1813-14 is given. January, 1823, is described as a month of exceptionally heavy snowstorms, " six to seven feet deep on the roads to Scotland—much ice accumulated in the Thames, the navigation of which was for some time suspended as to the smaller vessels." A drought is recorded in the summer of 1826. The summer of 1834 appears to have been hot in Scotland, but the only evidence of its high temperature is contained in the following extract from the Kelso Mail: " as a singular proof of the extreme heat of the weather the whole of the honey contained in a bee-hive was melted by the heat of the sun and the bees drowned in their own sweets."

As the self-recording barometer was one of the earliest in use, it was to be expected that the records would lead to speculations. In one of his digressions on the barometer, Howard notes that southerly winds are usually associated with a falling barometer, and northerly winds with a rising barometer, and then goes on to say, " Now fair weather is always attended with evaporation : the Northerly winds coming with an increasing capacity for water as the air proceeds towards a warmer latitude. Every one of these periods marked by the upward curve may therefore be considered as *a little summer in itself*, in which the barometer rises from day to day by the accession of vapour ; until, this effect being counteracted by the approach to saturation, the pressure gradually finds its level ; and, decomposition ensuing, one of the short depressions intervenes, with more or less rain, to be succeeded by another ellipse [This refers to the shape of the barogram] and another summer-like period in the weather." The term " decomposition " it will be noticed, is used to indicate the separation of water (liquid or solid) from the mixture of air and water vapour.

As a tribute to Luke Howard's foresight, we quote another paragraph from the Introduction. " To promote, then, the study and *use* of the Barometer in connection with other meteorological instruments ; to give a stimulus to important inquiries, already set on foot, into the nature of the atmospheric waves and currents ; to occupy profitably the leisure of ingenious men,

and gratify a reasonable curiosity, are my objects in this publication. It is confessedly adapted rather to the use of the *dilettanti* in natural philosophy than of regular students: yet may the latter find in it many a problem on which to exercise their powers of investigation; to deduce cause from effect, and explore the intimate yet obscure relations between them, which make of Meteorology itself in their hands so profound a study."

Readers of *Barometrographia* will be interested to learn that the original instrument with which the curves were obtained is now an heirloom in the possession of Mr. Alfred Howard, of Chigwell.

Review

The Atmosphere and its Story. A Popular Presentation of the Science of Meteorology free from Technicalities and Formulæ. By E. Frith. Size $8 \times 5\frac{3}{4}$. pp. 204. London. The Epworth Press, 1924. 6s. Net.

MR. FRITH, who signs his preface at Pietermaritzburg, has written a pleasant, chatty book and given it a certain amount of local South African colour. The title and especially the subtitle are rather misleading however, and to that extent unfair to the unwary purchaser who thinks that he will find the difficulties of meteorology smoothed by the use of simple language, the fact being that the difficulties are hardly ever faced, the story is not half told. It is tantalising to come to the chapter heading "Why it Rains," and read "In South Africa we know something of long and dreary droughts, when we see the yellow earth sicken with thirst and the parched-up gardens and mealie lands languish for the refreshing rains. After weeks of weary waiting the heavy cumulo-nimbus clouds roll up, charged with their welcome water; the air grows sultry and still, and the animals, birds and insects disport themselves in an expectant manner. The lightning flashes, the thunder peals, and down comes the rain." A reader who had been in the habit of thinking of the clouds as so many bags of water waiting to burst would not be enlightened by this paragraph, and, indeed, he might go through the whole chapter without making much progress towards understanding why it rains. Incidentally it may be regretted that there are not detailed observations of how the animals, birds and insects disport themselves "in an expectant manner."

We like some of the tit-bits of information which Mr. Frith has gleaned from various sources: "The approximate death rate per million due to lightning in the United Kingdom is one, Belgium two, Sweden and France three each, Prussia four, United States of America eight; but if the accurate record for South Africa were known it would amaze the world";

"The Emperor Augustus suffered from most distressing emotions when a thunderstorm was in progress, and he was in a habit of retiring to a chamber underground;" "The Eiffel Tower was struck by lightning on the 19th of August, 1889. The discharge struck the principal conductor at the summit; it was accompanied by a terrific noise resembling the detonation of several pieces of artillery, but none of the four persons at the top of the tower experienced the least inconvenience at the time of the flash, neither were any of the meteorological instruments damaged."

It should be added that the publishers have used exceptionally nice type and made a book which it is a pleasure to handle; the illustrations, mostly cloud photographs by Mr. E. G. Bilham, are well reproduced.

News in Brief

WE regret to announce the death, on April 9th, of Mr. George Marwood Watson, B.Sc., A.R.C.S., Junior Professional Assistant in the Meteorological Office, who had been engaged on work for the Atmospheric Pollution Committee since 1919.

We regret to learn of the death of Mr. John Maximilian Dyer, at Southbourne-on-Sea, in January this year. Mr. Dyer, who had been a master at Eton from 1888 to 1911, will be remembered by meteorologists as a volunteer who did good work in the preparation of the Admiralty Handbooks during the war.

The degree of Ph.D. has been conferred on J. Glasspoole by the University of London for a thesis dealing with the rainfall of the British Isles. The thesis included four papers which have recently been published, three in *British Rainfall* and one in the *Proceedings of the Institution of Water Engineers.*

It is stated* that at Les Alpilles Aerodrome, near St. Remy-en-Provence, Sergeant Vernard of the French Army made, if the report is accepted, a new world's "record" for gliding. He remained in the air, with the engine of his aeroplane stopped, for 9 hours 17 minutes. The previous record, 9 hours 8 minutes, was set up by Lieut. Thoret in August, 1924.

The Weather of March, 1925

OVER the British Isles generally the rainfall for March was scanty, the pressure high, and the total sunshine for the month below normal, except in the south-west. In the rear of a depression associated with local thunderstorms in south-east England

**The Times,* March 12th, 1925.

on the 1st, an anticyclone moved southwards over the Atlantic from Iceland, causing generally fair weather in the west. The eastern districts, however, came under the influence of a depression centred over the south of France, and cloudy weather occurred with high north-easterly winds and gales in the English Channel on the 3rd and 4th. During the next few days the winds backed towards the west and the weather became temporarily milder, 56° F. was reached at Kilkenny on the 6th: but a rapid rise of pressure near Iceland on the 7th resulted in a renewal of northerly winds which attained gale force in some places on the 8th. Showers of snow, sleet and hail were of general occurrence, and maximum temperature readings of below 35° F. occurred on one or two days; at Inverness on the 8th, the temperature did not rise above 32° F., and, at Andover, a grass minimum reading of 9° F. was recorded on the night of the 12th-13th. Between the 13th and 19th, the air over the British Isles was mainly drawn from a westerly source, the weather was fair and temperature rose above 55° F. on several occasions, reaching 60° F. at Kilkenny and Killarney on the 15th. Mist or fog developed locally in the early morning of most of these days. On the 19th, there was a return of the northerly winds and cold generally cloudy weather prevailed from then until the 30th. Showers of snow, hail and rain occurred generally and "snow lying" was again recorded in several places, notably on the 22nd, when the depth reported from Balmoral and also at Skegness and at Folkestone was between 2 and 3 inches. The readings of thermometers exposed over the snow were below 20° F. in some places, the reading at Balmoral on the night of the 22nd-23rd being as low as 6° F. By the 30th, the centre of the high pressure area had moved far enough south to give a warm south-westerly current from the Azores to Scandinavia. Heavy rain or snow fell in many parts of Scotland and north Ireland, 37 mm. (1·45 in.) fell at Dunfanaghy (Donegal) and 34 mm. (1·34 in.) at Renfrew.

In most parts of southern and central England and eastern and central Ireland, the total fall was less than 25 mm. (1 in.). At Purton, in Wiltshire, there was no measureable rain throughout the month.

Pressure was above normal over the greater part of the North Atlantic Ocean, western and northern Europe and at Spitsbergen, the excess being 14 mb. at Malin Head, about 7 mb. over Iceland and Spitsbergen and 13 mb. at the point 50° N, 30° W. Over the Azores and the western Mediterranean pressure was slightly below normal. Temperature was slightly below normal over most of western Europe, but at Spitsbergen the abnormally high temperature experienced from November to February still continued, the March mean being 14·5° F. above normal. On the

10th and towards the end of the month cold weather prevailed over Spain, a temperature of 12° F. being recorded at Estangento and Pvigcerdà on the 10th and at Estangento on the 22nd and 23rd. In Italy and Bulgaria conditions were mild during the first week, but later heavy snow fell in Bulgaria, a depth of 18 in. being reported from Sofia. A heavy snowstorm and high north-west winds occurred in Holland on the 8th. Towards the middle of the month, strong north-east winds and heavy seas were experienced off the Balearic Isles. Rainfall generally showed a slight deficit in western Europe. In Sweden pressure was normal in the east and about 3mb. above normal in the west. A cold spell occurred between the 7th and 16th over the country generally, temperature being about 14° F. below normal on most of these days. The rainfall distribution was irregular.

During the severe storm over Kiushiu (Japan) on March 12th, a passenger steamer was sunk near Nagasaki and it is feared many of the boats of the fishing fleet were lost.

In Rhodesia and South Africa heavy rainfall has been experienced throughout the month. The Orange river is said to have risen 37 feet,* cutting off railway communications with the south-west. An accident in which several people were killed occurred on the Cape-Natal railway near Hartshill on the 21st, owing to the collapse of the bridge over the Tugela river after the heavy rains.

On the 18th, a tornado swept across five of the Middle-West States of America, causing widespread disaster. It struck Annapolis (Missouri) about 13h. and then traversed southern Illinois, Indiana, central Kentucky and Tennessee. Many towns and villages were wiped out.

The rainfall in Australia and Tasmania was generally below normal except in North Kimberley, northern Queensland and along the north-eastern coasts of New South Wales.

The special message from Brazil states that the rainfall was scanty in the northern districts, being 34 mm. below the average, but that in the central and southern districts the rainfall was plentiful, being 41 mm. and 25 mm. above normal respectively. The pressure distribution during the month was normal. There is a general improvement in the crops due to the breakdown of the dry spell. Pressure at Rio de Janeiro was 0·4 mb. above normal and temperature 1·6° F. below normal.

Rainfall March, 1925—General Distribution

England and Wales ..	47	per cent. of the average 1881-1915.
Scotland	81	
Ireland	41	
British Isles	54	

*See *The Times*, March 24th, 1925.

Rainfall: March, 1925: England and Wales

CO.	STATION.	In.	mm.	Per-cent. of Av
Lond.	Camden Square	·68	17	37
Sur.	Reigate, Hartswood	·74	19	34
Kent.	Tenterden, View Tower	1·12	28	52
,,	Folkestone, Boro. San.	1·14	29	...
,,	Broadstairs, St. Peter's	1·22	31	73
,,	Sevenoaks, Speldhurst.	1·07	27	...
Sus.	Patching Farm	·71	18	33
,,	Brighton, Old Steyne	...	...	...
,,	Tottingworth Park	1·13	29	45
Hants	Ventnor, Roy. Nat. Hos.	·44	11	21
,,	Fordingbridge, Oaklnds	·37	9	16
,,	Ovington Rectory	·86	22	33
,,	Sherborne, St. John Rec.	·42	11	19
Berks	Wellington College	·58	15	29
,,	Newbury, Greenham	·50	13	22
Herts.	Bennington House	·80	20	44
Bucks	High Wycombe	·73	19	37
Oxf.	Oxford, Mag. College	·48	12	31
Nor.	Pitsford, Sedgebrook	·88	22	50
,,	Eye, Northolm	·70	18	...
Beds.	Woburn, Crawley Mill	·73	19	41
Cam.	Cambridge, Bot. Gdns.	·93	23	63
Essex	Chelmsford, County Lab	1·07	27	62
,,	Lexden, Hill House	1·15	29	...
Suff.	Hawkedon Rectory	1·31	33	69
,,	Haughley House	1·09	28	...
Norf.	Beccles, Geldeston	1·52	39	88
,,	Norwich, Eaton	1·76	45	92
,,	Blakeney	1·37	35	84
,,	Swaffham	1·84	47	103
Wilts.	Devizes, Highclere	·45	11	21
,,	Bishops Cannings	·39	10	17
Dor.	Evershot, Melbury Ho.	·59	15	20
,,	Weymouth, Westham	·56	14	27
,,	Shaftesbury, Abbey Ho.	·80	20	34
Devon	Plymouth, The Hoe	·46	12	16
,,	Polapit Tamar	1·13	29	38
,,	Ashburton, Druid Ho.	·64	16	14
,,	Cullompton	·52	13	19
,,	Sidmouth, Sidmount	·40	10	16
,,	Filleigh, Castle Hill	1·36	35	...
,,	Barnstaple, N. Dev. Ath.	1·08	27	41
Corn.	Redruth, Trewirgie	·86	22	24
,,	Penzance, Morrab Gdn.	·81	21	25
,,	St. Austell, Trevarna	1·36	35	40
Soms	Chewton Mendip	·57	15	16
,,	Street, Hind Hayes	·53	13	...
Glos.	Clifton College	·54	14	21
,,	Cirencester	·46	12	19
Here.	Ross, Birchlea	·52	13	26
,,	Ledbury, Underdown	·42	11	22
Salop	Church Stretton	1·27	32	54
,,	Shifnal, Hatton Grange	1·01	26	55
Staff.	Tean, The Heath Ho.	·99	25	42
Worc.	Ombersley, Holt Lock	·60	15	35
,,	Blockley, Upton Wold	·90	23	42
War.	Farnborough	·79	20	37
War.	Birmingham, Edgbaston	1·10	28	58
Leics	Thornton Reservoir	1·24	31	67
,,	Belvoir Castle	1·07	27	59
Rut.	Ridlington	1·12	28	...
Linc.	Boston, Skirbeck	1·37	35	88
,,	Lincoln, Sessions House	·80	20	52
,,	Skegness, Estate Office.	1·76	45	106
,,	Louth, Westgate	1·98	50	93
,,	Brigg	1·33	34	73
Notts.	Worksop, Hodsock	·78	20	46
Derby	Mickleover, Clyde Ho.	·93	24	52
,,	Buxton, Devon. Hos.	2·28	58	55
Ches.	Runcorn, Weston Pt.	·84	21	42
,,	Nantwich, Dorfold Hall	1·06	27	...
Lancs	Manchester, Whit. Pk.	1·16	29	51
,,	Stonyhurst College	2·16	55	59
,,	Southport, Hesketh	1·05	27	47
,,	Lancaster, Strathspey	1·20	31	...
Yorks	Sedbergh, Akay	2·10	53	46
,,	Wath-upon-Dearne	·60	15	34
,,	Bradford, Lister Pk.	1·05	27	43
,,	Wetherby, Ribston H.	·79	20	41
,,	Hull, Pearson Park	1·25	32	69
,,	Holme-on-Spalding	1·05	27	...
,,	West Witton, Ivy Ho.	1·27	32	...
,,	Felixkirk, Mt. St. John	1·61	41	82
,,	Pickering, Hungate	1·47	37	...
,,	Scarborough	1·79	45	99
,,	Middlesbrough	1·52	39	97
,,	Baldersdale, Hury Res.	1·82	46	60
Durh.	Ushaw College	1·52	39	69
Nor.	Newcastle, Town Moor.	1·73	44	82
,,	Bellingham Manor	2·79	71	...
,,	Lilburn Tower Gdns.	2·08	53	...
Cumb	Geltsdale	2·81	71	...
,,	Carlisle, Scaleby Hall	1·52	39	62
,,	Seathwaite M.	4·70	119	42
Glam.	Cardiff, Ely P. Stn.	·44	11	14
,,	Treherbert, Tynywaun	1·52	39	...
Carm	Carmarthen Friary	1·89	48	50
,,	Llanwrda, Dolaucothy	2·90	74	63
Pemb	Haverfordwest, School	1·58	40	46
Card.	Gogerddan	1·93	49	56
,,	Cardigan, County Sch.	1·05	27	...
Brec.	Crickhowell, Talymaes	1·50	38	...
Rad.	Birm. W. W. Tyrmynydd	2·51	64	47
Mont.	Lake Vyrnwy	2·12	54	50
Denb.	Llangynhafal	·97	25	...
Mer.	Dolgelly, Bryntirion	3·13	79	63
Carn.	Llandudno	·90	23	41
,,	Snowdon, L. Llydaw 9	6·07	154	...
Ang.	Holyhead, Salt Island	·67	17	26
,,	Lligwy	·75	19	...
Isle of Man				
	Douglas, Boro' Cem.	1·70	43	57
Guernsey				
	St. Peter P't, Grange Rd	·67	17	27

Rainfall: March, 1925: Scotland and Ireland

CO.	STATION	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent. of Av.
Wigt.	Stoneykirk, Ardwell Ho	1·38	35	53	*Suth.*	Loch More, Achfary	8·24	209	128
,,	Pt. William, Monreith	1·20	31	...	*Caith*	Wick	2·31	59	102
Kirk.	Carsphairn, Shiel.	3·48	88	...	*Ork.*	Pomona, Deerness	3·04	77	108
,,	Dumfries, Cargen	1·14	29	32	*Shet.*	Lerwick	2·69	68	86
Dum	Drumlanrig	1·21	31	32					
Roxb	Branxholme	2·45	62	84	*Cork.*	Caheragh Rectory	·59	15	...
Selk.	Ettrick Manse	2·60	66	...	,,	Dunmanway Rectory	·71	18	14
Berk.	Marchmont House	3·04	77	115	,,	Ballinacurra	·24	6	8
Hadd	North Berwick Res.	2·15	55	114	,,	Glanmire, Lota Lo.	·35	9	11
Midl	Edinburgh, Roy. Obs.	2·26	57	128	*Kerry*	Valencia Obsy.	1·03	26	23
Lan.	Biggar	2·07	53	84	,,	Gearahameen	2·30	58	...
Ayr.	Kilmarnock, Agric. C.	2·18	55	78	,,	Killarney Asylum	2·12	54	45
,,	Girvan, Pinmore	1·42	36	38	,,	Darrynane Abbey	1·34	34	33
Renf.	Glasgow, Queen's Pk.	1·64	42	63	*Wat.*	Waterford, Brook Lo.	·54	14	20
,,	Greenock, Prospect H.	3·55	90	72	*Tip.*	Nenagh, Cas. Lough	·73	19	24
Bute.	Rothesay, Ardencraig.	3·52	89	98	,,	Tipperary	·89	23	...
,,	Dougarie Lodge	2·65	67	...	,,	Cashel, Ballinamona	·47	12	17
Arg.	Ardgour House	6·00	152	...	*Lim.*	Foynes, Coolnanes	·54	14	18
,,	Manse of Glenorchy	4·22	107	...	,,	Castleconnell Rec.	·83	21	...
,,	Oban	2·39	61	...	*Clare*	Inagh, Mount Callan	1·53	39	...
,,	Poltalloch	3·02	77	79	,,	Broadford, Hurdlest'n.	·95	24	...
,,	Inveraray Castle	4·56	116	72	*Wexf*	Newtownbarry	·61	15	...
,,	Islay, Eallabus	2·86	73	75	,,	Gorey, Courtown Ho.	·44	11	19
,,	Mull, Benmore	6·80	173	...	*Kilk.*	Kilkenny Castle	·91	23	40
Kinr.	Loch Leven Sluice	1·48	38	50	*Wic.*	Rathnew, Clonmannon	·54	14	...
Perth	Loch Dhu	2·90	74	44	*Carl.*	Hacketstown Rectory	·89	23	32
,,	Balquhidder, Stronvar.	2·08	53	34	*QCo.*	Blandsfort House	·69	17	26
,,	Crieff, Strathearn Hyd.	1·26	32	39	,,	Mountmellick	·50	13	...
,,	Blair Castle Gardens	2·13	54	81	*KCo.*	Birr Castle	·47	12	20
,,	Coupar Angus School	1·29	33	59	*Dubl.*	Dublin, FitzWm. Sq.	·64	16	33
Forf.	Dundee, E. Necropolis.	1·43	36	69	,,	Balbriggan, Ardgillan	·53	13	26
,,	Pearsie House	1·40	36	...	*Me'th*	Drogheda, Mornington	·47	12	...
,,	Montrose, Sunnyside	1·10	28	53	,,	Kells, Headfort	·65	17	24
Aber.	Braemar Bank	2·30	58	78	*W.M*	Mullingar, Belvedere	·69	17	26
,,	Logie Coldstone Sch.	2·77	70	107	*Long*	Castle Forbes Gdns.	·79	20	27
,,	Aberdeen, Cranford Ho	...	...	...	*Gal.*	Ballynahinch Castle	1·81	46	35
,,	Fyvie Castle	2·97	75	...	*Mayo*	Mallaranny	2·78	71	...
Mor.	Gordon Castle	2·35	60	101	,,	Westport House	1·77	45	45
,,	Grantown-on-Spey	3·67	93	139	,,	Delphi Lodge	2·75	70	...
Na.	Nairn, Delnies	1·96	50	105	*Sligo*	Markree Obsy.	1·75	44	52
Inv.	Ben Alder Lodge	3·90	99	...	*Cav'n*	Belturbet, Cloverhill	·92	23	33
,,	Kingussie, The Birches	2·67	68	...	*Ferm*	Enniskillen, Portora	1·35	34	...
,,	Loch Quoich, Loan	8·50	216	...	*Arm.*	Armagh Obsy.	1·20	31	51
,,	Glenquoich	7·47	190	77	*Down*	Warrenpoint	·82	21	...
,,	Inverness, Culduthel R.	1·79	46	...	,,	Seaforde	·94	24	32
,,	Arisaig, Faire-na-Squir	2·67	68	...	,,	Donaghadee, C. Stn.	·70	18	32
,,	Fort William	4·24	108	64	,,	Banbridge, Milltown	1·03	26	47
,,	Skye, Dunvegan	2·94	75	...	*Antr.*	Belfast, Cavehill Rd.	1·86	47	...
,,	Barra, Castlebay	1·64	42	...	,,	Glenarm Castle	2·40	61	...
R&C	Alness, Ardross Cas.	3·30	84	101	,,	Ballymena, Harryville	2·59	66	82
,,	Ullapool	5·44	138	...	*Lon.*	Londonderry, Creggan	4·58	116	143
,,	Torridon, Bendamph.	7·66	195	102	*Tyr.*	Donaghmore	1·64	42	...
,,	Achnashellach	7·00	178	...	,,	Omagh, Edenfel	2·00	51	64
,,	Stornoway	3·93	100	96	*Don.*	Malin Head	2·56	65	111
Suth.	Lairg	2·89	73	...	,,	Rathmullen	4·16	106	...
,,	Tongue Manse	2·82	72	84	,,	Dunfanaghy	4·01	102	110
,,	Melvich School	3·54	90	124	,,	Killybegs, Rockmount	3·24	82	64

Climatological Table for the British Empire, October, 1924

STATIONS	PRESSURE Mean of Day M.S.L. mb.	PRESSURE Diff. from Normal mb.	TEMPERATURE Absolute Max. °F.	TEMPERATURE Absolute Min. °F.	TEMPERATURE Mean Values Max. °F.	TEMPERATURE Mean Values Min. °F.	TEMPERATURE Mean Values ½ max. and min. °F.	TEMPERATURE Mean Values Diff. from Normal °F.	TEMPERATURE Mean Wet Bulb °F.	Relative Humidity %	Mean Cloud Am'nt 0—10	PRECIPITATION Am'nt mm.	PRECIPITATION Diff. from Normal mm.	PRECIPITATION Days	BRIGHT SUNSHINE Hours per day	BRIGHT SUNSHINE Percentage of possible
London, Kew Obsy.	1013·3	− 0·7	68	33	57·5	46·8	52·1	+ 2·2	49·9	85	7·5	92	+ 23	14	2·0	18
Gibraltar	1017·8	+ 0·6	79	55	72.1	60·5	66·3	+ 0·2	61·4	75	5·1	41	− 43	6	...	...
Malta	1017·4	+ 1·7	80	63	75·5	67·4	71·5	+ 1·7	66·1	75	5·3	125	+ 57	13	5·9	52
Sierra Leone	1013·1	+ 1·1	88	67	85·9	70·6	78·3	− 1·9	75·2	79	5·4	191	−130	23	...	...
Lagos, Nigeria	1010·9	− 0·8	87	70	85·0	73·5	79·3	+ 0·2	75·9	81	7·2	397	+201	22	...	...
Kaduna, Nigeria	1014·0	+ 1·7	91	65	87·4	69·7	78·5	+ 2·2	73·9	82	0·8	26	− 34	5	...	...
Zomba, Nyasaland	1010·8	+ 0·3	92	54	85·3	62·9	74·1	0·0	...	75	4·7	22	− 16	4	...	...
Salisbury, Rhodesia	1009·5	− 1·4	91	51	82·5	58·0	70·3	− 0·5	59·3	49	3·3	48	+ 18	7	...	...
Cape Town	1017·2	− 0·2	78	40	69·0	51·8	60·4	− 0·6	57·1	70	4·8	46	+ 2	9	...	...
Johannesburg	1014·2	− 0·2	82	42	72·5	51·3	61·9	− 0·7	51·6	61	5·1	58	− 3	11	8·5	67
Mauritius	1017·1	− 1·1	81	55	77·9	61·7	69·8	− 2·9	...	70	6·3	82	+ 47	13	6·8	55
Bloemfontein	...	...	84	37	76·5	49·0	62·7	− 1·9	52·9	51	3·7	39	− 4	5	...	...
Calcutta, Alipore Obsy.	1008·4	− 1·0	95	72	88·6	76·4	82·5	+ 1·8	76·7	86	3·5	83	− 16	9*	...	...
Bombay	1010·1	+ 0·4	91	73	87·4	75·9	81·7	− 0·6	74·2	78	4·4	2	− 45	0*	...	...
Madras	1008·7	− 0·2	95	71	90·4	75·9	83·1	+ 1·0	76·7	79	5·1	122	−164	10*	...	...
Colombo, Ceylon	1010·2	+ 0·4	89	72	85·8	75·3	80·5	0·0	77·3	72	7·0	368	+ 11	18	7·5	63
Hong Kong	1012·3	− 1·3	89	64	81·2	72·7	76·9	0·0	70·0	71	6·4	231	+106	9	6·2	54
Sandakan	...	...	90	72	88·2	74·8	81·5	0·0	76·8	79	...	270	+ 16	15	...	...
Sydney	1011·2	− 3·7	90	46	73·7	55·8	64·7	+ 1·2	56·6	58	4·9	32	− 43	8	7·2	56
Melbourne	1009·4	− 5·3	81	41	66·6	48·6	57·6	0·0	53·1	64	6·9	100	+ 34	19	5·3	39
Adelaide	1010·1	− 6·0	89	41	72·3	51·9	62·1	+ 0·2	53·4	53	5·4	51	+ 7	13	6·8	53
Perth, W. Australia	1014·1	− 2·8	79	41	65·9	50·9	58·4	− 2·5	53·4	68	5·4	140	+ 86	18	7·1	55
Coolgardie	1011·1	− 4·1	88	36	74·2	48·6	61·4	− 2·2	52·5	38	4·8	19	0	4	...	...
Brisbane	1013·7	− 2·4	87	51	79·0	60·9	69·9	0·0	63·9	63	4·5	41	− 26	7	7·6	60
Hobart, Tasmania	1003·2	− 7·4	80	38	61·9	45·8	53·9	− 0·1	48·1	63	7·1	67	+ 10	22	5·4	41
Wellington, N.Z.	1007·3	− 5·0	67	45	62·9	51·5	57·2	+ 2·9	...	72	7·1	116	+ 9	15	4·8	37
Suva, Fiji	1012·8	− 0·4	87	65	81·0	69·1	75·1	− 0·9	71·5	75	5·5	319	+121	14	...	...
Apia, Samoa	1011·9	+ 0·4	89	71	85·4	73·3	79·4	+ 1·0	76·2	82	5·7	205	+ 51	16	6·7	54
Kingston, Jamaica	1011·2	− 0·3	91	69	87·4	71·7	79·5	− 1·0	74·5	78	7·0	264	+ 74	16	...	...
Grenada, W.I.	1012·0	+ 1·0	89	71	84·9	74·9	79·9	− 0·2	76·3	81	5·7	299	+113	22	...	...
Toronto	1023·4	+ 5·4	72	31	60·8	40·4	50·6	+ 3·7	43·7	79	2·5	15	− 47	6	7·0	63
Winnipeg	1014·2	− 1·1	78	28	60·5	41·0	50·7	+ 9·9	...	...	4·5	69	+ 31	7	5·3	49
St. John, N.B.	1016·6	+ 0·1	67	28	54·9	39·8	47·3	+ 2·0	43·0	81	4·3	56	− 59	8	5·9	54
Victoria, B.C.	1012·7	− 4·9	64	40	56·7	46·2	51·5	+ 1·1	48·0	86	6·9	79	+ 14	19	4·8	44

* For Indian stations a rain day is a day on whi[illegible] ·5 mm.) or more rain h[illegible] fallen.

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